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Saltmarsh Relocation Restoration in Maine

Maine Department of Transportation

Reed & D'Andrea

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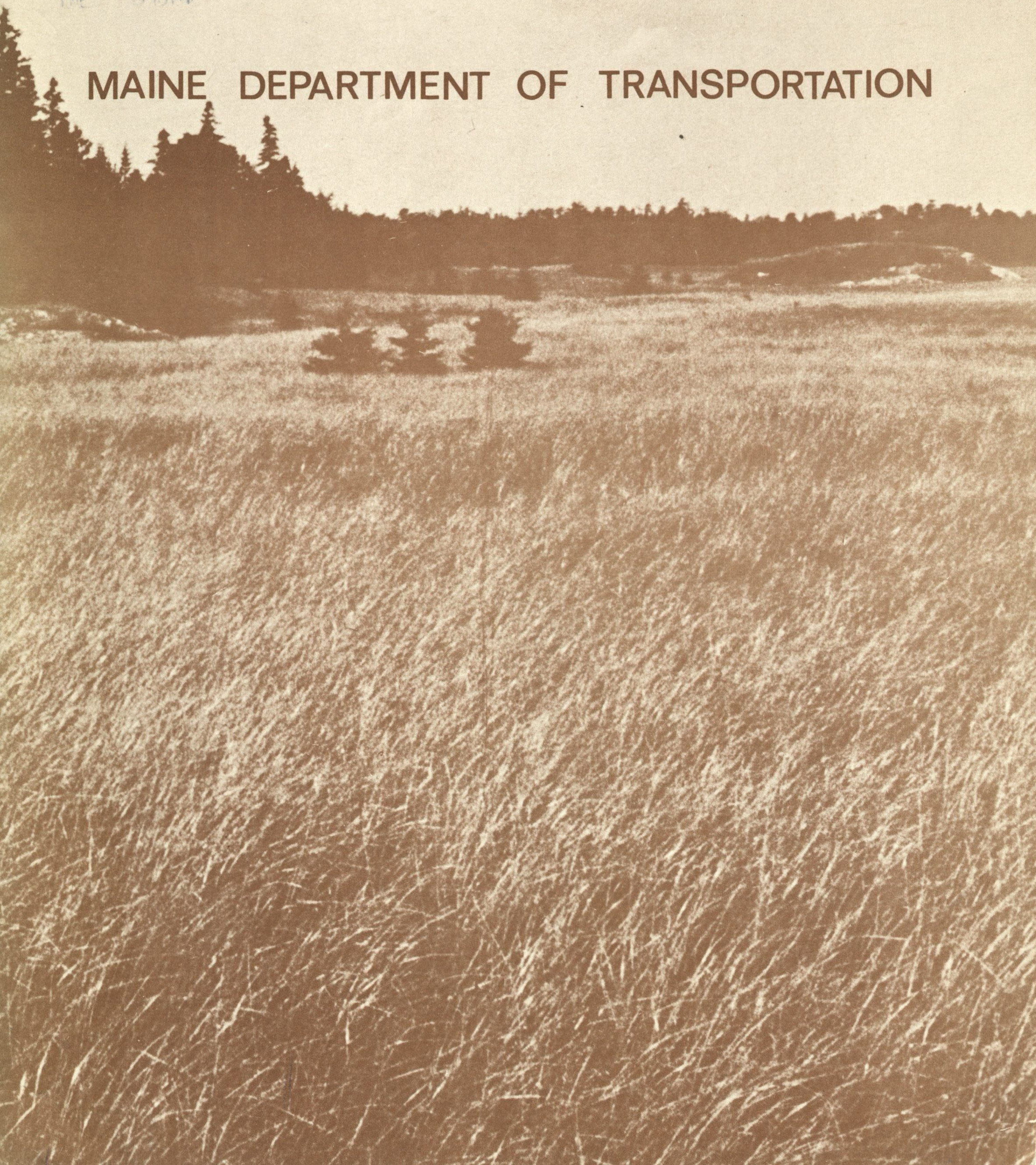
MAINE DEPARTMENT OF TRANSPORTATION



SALTMARSH RELOCATION RESTORATION IN MAINE

Prepared for

THE MAINE DEPARTMENT OF TRANSPORTATION
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PREFACE

This report represents the final product of a study commissioned by the Maine Department of Transportation July 5, 1973, and conducted by the firm of Reed & D'Andrea (South Gardiner, Maine). The objective of the study was to determine the feasibility of enhancing the extent of Maine's salt marshes through relocation or restoration.

Relocation of marshes was determined a viable alternative to unavoidable salt marsh destruction by highway construction; in the course of the study, its use in stabilizing areas undergoing or subject to rapid erosion was also investigated. Restoration aspects were considered for the purpose of restoring areas inadvertently damaged or destroyed.

Previous to this report, three interim reports were issued. A "Background Report" (October 2, 1973) detailed the state of the art in salt marsh relocation/restoration and reviewed the literature for any pertinent data. A second report "Workshop Report" (December 12, 1973), described the results of a workshop held to acquaint experts in the field with the Maine situation and to introduce the concept of marsh relocation to various interested state and private individuals. A third report was issued February 27, 1974, entitled "Final Recommendatons Report." These three reports are now incorporated in the present final report.

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background report

ABSTRACT

Salt marsh restoration and relocation is examined as an alternative to marsh losses from construction activities or as a means of stabilizing erosion. Procedures developed on the coasts of Maryland and North Carolina are examined, and factors affecting the transferability of these to the Maine coast detailed. The existing literature on biological, physical, and economic considerations is reviewed, including:

1. Appropriate plant species for marsh propogation, their nutrient requirements, productivity, and intraspecies variation.
2. Location in terms of tidal influence and substrate.
3. Effect of sedimentation, erosion, ice and other physical stresses on established and newly formed marsh environments.
4. Benefits derived from salt marshes, direct and indirect.
5. Costs involved in artificial marsh propogation.

Finally, site selection criteria are discussed based on the previous review.

Introduction

The Maine Department of Transportation (DOT) is sponsoring a feasibility study of salt marsh restoration/relocation in Maine. This study basically concerns determining the factors involved in marsh restoration projects and how those factors can be used to evaluate potential sites for marsh building projects on the Maine coast.

Marsh restoration is a process just recently developed on the coasts of Maryland and North Carolina. To date it has not been attempted, or even investigated north of Long Island, New York. The Maine Department of Transportation is interested in marsh restoration as an alternative to marsh losses from road construction projects near the coast of Maine. Feasibility of the project can only be determined after a thorough understanding of the parameters involved with the restoration process (biological, physical, and economic) and the specific problems that may be incurred in a restoration project in Maine.

This report describes the state of the art of marsh restoration and the parameters as they have been described in the literature. Some conclusions are drawn as to how those parameters can be interpolated to Maine environmental and physical conditions. In addition, a preliminary list of site selection criteria is presented. This list summarizes existing information concerning salt marsh restoration.

State of the Art

Salt marsh restoration is a relatively new activity which has made outstanding progress in the past few years. Actual marsh building was initiated in two independent projects, the first on the North Carolina coast beginning in 1970 (Woodhouse, Seneca, and Broome 1972) and the second in Chesapeake Bay beginning in 1972 (Garbisch 1973). The events leading up to the first marsh restoration projects deserve mention and help illustrate the philosophy behind their inception. The development of an applied approach to coastal marshland management through marsh restoration cannot be overemphasized. The intrinsic value of salt marshes to the marine ecosystem as well as to man has been recognized by Woodhouse *et al.* and Garbisch. This is not new knowledge, but until now has been utilized mostly by preservation oriented conservationists. A significant step forward was made by the effort to enhance salt marsh acreage and to reconstruct the damage that has been done by the destruction of so much of the Atlantic coast salt marshlands.

The two landmark studies in marsh restoration provide the basis of existing data for the planning and analysis of future marsh projects. The investigations of Woodhouse *et al.* (1972) considered several variables and techniques for establishing salt marsh vegetation (primarily *Spartina alterniflora*) on newly deposited dredge spoil. Variations included different substrate types, planting methods, planting locations, plant sources, and elevation. This project established the feasibility of developing salt marshes and subsequent dredge spoil stabilization by seeding and transplanting *Spartina alterniflora* on intertidal spoil sites. Studies have been continued by Broome, Woodhouse and Seneca (1973) to determine the best methods for propagation of *Spartina alterniflora* and the fertilizing requirements of newly established marshlands.

In a similar project in the Chesapeake Bay, Garbisch (1973) planted two acres of intertidal sand near Hambleton Island (St. Michaels, Maryland) with nine species of marsh plants. The most successful species was *Spartina alterniflora* which colonized substantial portions of the area

and attracted a wide variety of characteristic marsh fauna including racoons, muskrats, and Canada geese. Garbisch and his associates at Environmental Concern, Inc., are currently engaged in several marsh building projects, mostly using dredge spoil as substrate. In addition to continuing research on regeneration, Environmental Concern, Inc., plans to pursue the practical aspects of marsh construction by acting as consultants for new projects, and providing seedlings of Spartina alterniflora for a limited number of marsh projects (E. W. Garbisch, personal communication).

The Marine Sciences Research Center of the State University of New York (Stony Brook) under the leadership of Dr. Orville Terry is undertaking a small marsh restoration project on Long Island. The project hopes to stabilize shoreline spoil areas which are under extreme stress (Terry, personal communication). Results from this project will be most important in relating the work that has been done in the more southerly marshes of North Carolina and Maryland to the more demanding environment in the northeast.

In Maine, a related but quite distinct project is being conducted by a private industrial concern. The S. D. Warren Company, Division of Environmental Protection, is transplanting eelgrass (Zostera marina) in the Presumpscot River estuary. In addition to establishing basic data on the tolerance and distribution of eelgrass, the project has developed successful techniques for establishing new eelgrass beds to stabilize subtidal sediments, trap suspended particles, and add to the overall productivity of the estuary (Weymouth, personal communication).

Salt Marsh Restoration in Maine

In response to the success of the salt marsh projects of Environmental Concern, Inc., and Woodhouse et al., the Maine Department of Transportation initiated this study to determine the feasibility of marsh restoration in Maine. In understanding the value and fragility of marshland, DOT is actively investigating the desirability and feasibility of building salt marshes in conjunction with transportation projects whose design and location constraints dictate involvement with coastal areas. Interest has also been generated in the state of Maine for increasing the absolute salt marsh acreage in addition to preserving the existing marsh lands.

Before adequate recommendations can be made concerning the feasibility or advisibility of salt marsh restoration in Maine, the parameters of salt marsh establishment and development in the northeast and how they relate to the techniques and limitations of regeneration must be determined. Although little recognized work has been done specifically on Maine marsh lands, several factors have been discussed in the literature and can be related to Maine's conditions.

Parameters of Marsh Restoration - Literature Review

The literature describing salt marshes of the east coast of North America is voluminous. Popular accounts of tidal marshes have become very common, especially since the onset of the ecological movement in the late 1960's. Teal and Teal (1969) present an excellent generalized picture of the structure, function, and stresses on salt marshes of the northeast. Chapman (1960) synthesizes the scientific literature on the world's salt marshes. These and the subsequent excellent descriptive work by Redfield (1972) preclude a detailed description of marsh structure and function here. What will be noted, however, is that salt marsh structure is remarkably uniform throughout its range on the east coast of the United States. Distinct zones develop in relation to tidal extremes and substrate types, and are generally described below (from lower to upper elevations):

1. Low marsh from the mid-tide level to the normal limit of high water (almost entirely _Spartina alterniflora_).
2. Lower slope dominated by _Spartina patens_.
3. Upper slope dominated by _Juncus gerardi_ and _Distichlis spicata_.
4. The zone dominated by _Panicum virgatum_ which borders on the upland (Miller and Egler, 1950).

This overly simplified picture of marsh zonation depicts the basic structure of marshes in the "Bay of Fundy," "New England," and "Coastal Plain" as described by Chapman (1960). On the basis of this similarity, studies that have been carried out in marshes of the southeastern United States can be related to marsh conditions in the northeast, keeping in mind variations caused by differences in the length of growing season, magnitude of tidal fluctuations, substrate variation, etc.

As a prerequisite to determining the feasibility of establishing new marsh lands on the Maine coast, a thorough understanding of the variables involved in the restoration process is essential. Many of these factors have been discussed in the literature. For the purpose of this report, the factors can be divided into the biological parameters, physical/geological parameters, and economic parameters. Many of the individual

factors discussed below intergrade considerably, and it should be kept in mind that this is an artificial scheme developed here for convenience.

Biological Parameters

Plant Species

In the marsh restoration projects attempted to date, the one species most effectively established in new marsh lands is salt marsh cord grass, _Spartina alterniflora_ (Woodhouse, _et al._ 1972, Garbisch 1973). A total of nine species of plants were used in Garbisch's test marsh at Hambleton Island. _Spartina alterniflora_ was found to be the species with the highest rate of survival, highest natural productivity, and was the most conducive to culture for transplanting into new intertidal marsh lands (Garbisch, personal communication).

Teal (1962) reported that _Spartina alterniflora_ is the only higher plant in the marsh that is important in the primary production of the marsh. (Due to severe physiological stress, species diversity in the salt marsh is low.) Cooper (1969) stated that _S. alterniflora_ makes a great contribution to the total energy budget of the estuary because detritus from the intertidal marsh is flushed regularly by the tide. Pomeroy (1959) showed that the algae which are common on the mud surface in stands of _S. alterniflora_ are also significant in the primary production of the marsh. In studies of primary productivity for Georgia salt marshes, Smalley (1959) found _S. alterniflora_ to be more than twice as productive as salt hay, _Spartina patens_.

Spartina alterniflora is represented by two varieties in most Atlantic coast marshes: a tall form (var. glabra) and a short form (var. pilosa). The tall form (var. glabra) is characteristic of the greater part of the intertidal alterniflora zone. According to Cooper (1969) and others, the short form (var. pilosa) is usually found on the upper margins of the zone. In Connecticut, Massachusetts, and New Hampshire marshes, Miller and Egler (1950), Chapman (1960), and Davis (1956) found var. pilosa restricted to the margins of salt pans. Redfield (1972) recognized var.

pilosa at or near the high water level where the marsh becomes flat in the Barnstable, Massachusetts, marsh. Studies done by Mooring, Cooper, and Seneca (1971) and Shea, Warren, and Neiring (1972) indicate that height differences are ecologically determined (ecophenes), not genetically determined as suggested by Stalter and Batson (1969) and others.

In terms of net productivity, Spartina alterniflora is as productive or more productive than any other phanerogam (flowering plant) in the marsh. Furthermore, var. glabra was found to be much more productive than var. pilosa (Udell, Zarudsky, Doheny, and Burkholder 1969, and Cooper 1969). Udell et al. (1969) estimated annual production for the marshes at Hempstead Bay (Long Island, New York) and found that S. alterniflora var. glabra produced an average of 827 g/m^2 whereas var. pilosa produced 508 g/m^2, Spartina patens 503 g/m^2, and Distichlis spicata 647 g/m^2. By comparison, Burkholder and Doheny (1968) found the total production of eelgrass (Zostera marina) to be 8 to 10 tons per acre (1,795-2,244 g/m^2) for favorable conditions in Hempstead Bay (eelgrass is found in the adjacent subtidal community).

Annual net production of Spartina alterniflora was shown by Cooper (1969) to vary with latitude. Productivity decreases with increasing latitude (Georgia 1,600 g/m^2, North Carolina 640 g/m^2, Delaware 360 g/m^2, New Jersey 325 g/m^2). This is apparently due to the length of the growing season. The growing season for the New Jersey marsh above was from late April through September. In Maine, the growing season generally lasts from early May through September along the coast. Productivity can be assumed similar to New Jersey's for the intertidal marsh.

Hence, in terms of growth and productivity, Spartina alterniflora marshland appears to be most suitable for restoration projects. Zostera marina also has potential for subtidal culture. Consequently the remaining factors affecting the feasibility of salt marsh restoration will be discussed relative to intertidal S. alterniflora and subtidal Z. marina communities.

Tidal Relationships

Tidal action has a most profound effect on the structure and function of the entire marsh complex. The intertidal marsh which is inundated by the tide two times each day is totally dominated by tidal influence. Factors affecting growth and survival of the vegetation are related to the relative periods of exposure and inundation (Woodhouse, Seneca, and Broome 1972).

Tidal amplitude governs the vertical range of the intertidal marsh. Generally, Spartina alterniflora occurs from about mean sea level (MSL) to about mean high water (MWH) (Miller and Egler 1950, Cooper 1969). According to Chapman (1960), with increasing latitude S. alterniflora var. glabra descends lower into the intertidal zone. Measurements given by Chapman show that lower limits range from MSL in the Gulf of Mexico, -1.6 feet MSL in North Carolina (Charleston), -1.9 feet MSL in Long Island, and -2.1 feet MSL in Boston. In addition, tidal amplitude generally increases with latitude so that the vertical range of S. alterniflora increases with latitude. To determine the amplitude for any particular marsh or area; local conditions, shoals, bottom topography, configuration of the estuary, and position in the estuary must be taken into account.

In many marshes, especially those of the northeast, Spartina alterniflora is restricted to the relatively narrow seaward margin of the marsh and borders of steep stream banks (Miller and Egler 1950, Chapman 1960). However, where slopes are gentle, the intertidal marsh may cover a very large area (Cooper 1969). In the Barnstable (Mass.) marsh studied by Redfield (1972), there are extensive areas of intertidal marsh. Maintenance of large intertidal acreage is dependant on stabilized erosion and sedimentation rates (discussed below).

Substrate

Salt marshes are known to occur on many different types of substrate. Chapman (1960) reviewed all the existing marsh types and found significant substrate variations in three categories of marshes on the east coast of North America (Bay of Fundy, New England, and Coastal Plain). An

abundance of silt is characteristic of both the Fundy-type marsh and coastal plain-type marsh, although local variations of texture are common. In New England, where there is little silt available, natural marshes have developed a bed of fibrous marsh peat in front of hard rock uplands. Peat accumulation, in conjunction with minor sedimentation accumulation in some cases, has kept pace with rising sea level to form thick peat deposits (Thompson 1973).

The studies by Woodhouse, Seneca, and Broome (1972) indicated that marshes can become established on a wide range of substrates. E. W. Garbisch (personal communication) has grown marshes on several different substrates. In Massachusetts Redfield (1972) found _Spartina alterniflora_ invading recently deposited barren sand flats via seeding, rhizome extension, and turf rafting. The intertidal marsh studied by Davis (1956) in New Hampshire was based on a substrate primarily composed of silts and clays. Particle sizes are generally classed as sand, 1-.05 mm; silt, .05-.002 mm; and clay under .002 mm diameter (Buckman and Brady 1969).

Substrate-related factors limiting the growth and development of the intertidal marsh include salinity, drainage (aeration) and substrate stability (Chapman 1960).

Woodhouse, Seneca, and Broome (1972) found toxic salt concentrations in some areas of marsh, probably where layers of clay and sand overlapped. This implies a restriction of drainage. Also, according to Redfield (1972), if a _Spartina alterniflora_ marsh is allowed to develop on a uniform, gently sloping area (hence well-drained), a uniform stand will result. Generally, if the substrate has a uniform texture (i.e. no impervious layers, uncompacted) and surface water is allowed to run off or percolate, soil conditions will be favorable for the development of _Spartina alterniflora_ in its normal intertidal range.

Artificial ditching of marshes for mosquito control has been a common practice in Atlantic coast marshes for many years. Bourn and Cottam (1950) found that ditching in a Delaware _Spartina alterniflora_ marsh (altering the natural drainage) eliminated the natural vegetation and replaced it with less productive species characteristic of the drier fringes of the natural marsh (_Pluchea_, _Iva_, _Baccharis_). These are brackish marsh composites not abundant in natural salt marshes.

Chapman (1960) indicated that in most marshes there is an upper aerated layer in the substrate that sustains root activity during submergence. This layer reportedly fluctuates greatly between marshes and even within a single marsh. The oxygen content varies and may be a limiting factor in the occurrence of some species in some parts of the marsh. Broome, Woodhouse, and Seneca (1973) suggested that different degrees of aeration affect chemical properties of the soil which, in turn, affect growth and development of the vegetation.

Nutrient supply in marsh soils was found by Broome et al. (1973) to limit productivity in some marshes. Adams (1963) found that the high iron requirement of Spartina alterniflora is a significant factor limiting its growth in the intertidal zone. Broome et al. (1973) also found that nitrogen and phosphorus fertilization of developing S. alterniflora marshlands improves the growth of seedlings and transplants. This is important for rapid establishment of vegetation on relatively unstable substrates. Potential exists for using sewage treatment wastes for marsh fertilization. This possibility should be investigated to determine the nutritional content of various end products from treatment processes, the absorption rate of the nutrients, the potential impact of the wastes on the non-marsh surroundings, and generally the efficiency of the wastes for marsh utilization. In addition, wastes should be examined for possible contaminants including heavy metals.

Conclusions from Biological Considerations

From the above discussion it appears that the intertidal Spartina alterniflora marsh is the most suitable type of marsh for artificial establishment or restoration projects. Because of its position in the intertidal zone and the consequent severe physiological stress, species diversity is low in the tidal marsh. This simplifies the marsh community, reduces competition, and increases productivity. A marsh can be established on many different substrate types, although fertilization may be necessary for good development on some soils.

Physical/Geological Parameters

The biological parameters affecting marsh restoration are more or less characteristic of the general Atlantic coast marshes and have uniform variations (e.g., vertical range of Spartina alterniflora with latitude). The physical/geological parameters, however, are much more variable and in most cases conditions vary from site to site. Consequently, these factors will be discussed here in terms of the northern New England-Maine region and the varying conditions that may occur in different parts of this area.

Sedimentation and Erosion

Wind, wave, and current action is often severe on the coast of Maine, especially during northeaster gales which are frequent during the winter. In contrast to the coast of southern New England, sedimentation and erosion are not major problems in Maine. This is because of the characteristic hard rock shoreline and resistant upland (Johnson, 1925). However, small scale, localized deposition and erosion are common because of upland runoff and local hydrodynamics (Farrell 1970, Colby 1963).

According to Chapman (1960) sediment accretion on salt marshes is generally greatest in areas adjacent to major creeks and in the lowest vegetative zone. The mechanical effect of the dense vegetation acts to trap suspended particles. Generally, the denser the vegetative cover and the more often it is flooded with particle laden water, the more rapidly sediment will build up on the marsh. However, Chapman also points out that the maximum rate of sediment accretion in New England marshes occurs during the early stages of marsh development from mud flats.

Redfield (1972) noticed that intertidal marshes so affect inshore currents that in Barnstable (Mass.) sediments were deposited adjacent to marsh areas. This provided new intertidal flats which could be colonized by Spartina alterniflora.

Erosion in established salt marshes is often caused by peak runoff in the tidal creeks. Hence creek banks are undercut and turf falls into the widened creek (Chapman 1960, Redfield 1972). In an intertidal marsh with uniform slope and uniform vegetation, drainage is uniform and creeks are generally absent. Large scale erosion is likely to occur when a newly established marsh is hit by storm waves, especially when exposed to storm currents.

A long range approach to sedimentation and/or substrate accretion has been discussed by several researchers. This usually takes the form of salt marsh development in relation to the rise of sea level. According to the most recent estimates of sea level rise on the Maine coast (Thompson 1973), the sea is currently rising at a rate of 0.06 meters/century (whereas 3,000 years ago it rose 1.15 meters/century). Several marshes have been shown to have developed in direct relation to this rise of sea level. Johnson (1925), Chapman (1960), Redfield (1972), Thompson (1973) and others have described flourishing marshes underlain by several feet of salt marsh peat. Some of the marshes described have formed over fresh water marsh or terrestrial vegetation. Marsh levels have apparently built up in response to rising sea levels.

This historical aspect of salt marsh development should not be overlooked when considering the ontogeny of a marsh and the prognosis for a newly established marsh.

Effect of Ice

Winters along the Maine coast are characteristically severe. Ice build-up in protected bays and estuaries is often very heavy, and on tidal rivers has been gauged at two to three feet in recent winters. Studies of the effects of ice on New England marshes have demonstrated that a tremendous force is exerted on a marsh by tidal ice (Batchelder 1926, Davis 1956, Redfield 1972). In the intertidal marsh, ice moves up and down with the tide; when not disturbed by storms, a large ice sheet forms on the marsh, which is later broken by excessive movement. Davis (1956) observed ice blocks over three feet thick on a New Hampshire marsh. Batchelder (1926)

noted that the ice blocks often freeze to the marsh surface at low tide and when the tide floods, the surface vegetation and peat layer is removed with the ice. Large pieces of turf transported by ice rafts were shown by Redfield (1972) to be a significant mechanism of spreading marshland to new intertidal areas.

The question of how ice affects the growth and development of a newly established intertidal marsh has not been successfully answered in the literature. The restoration experiments of Woodhouse et al. (1972) and Garbisch (1973) have not had to contend with the ice factor as it occurs in northern New England.

A correlation may exist between substrate texture (with resultant drainage and water content) and amount of damage due to ice. Investigation should be made into the exact effect of ice on the intertidal marsh.

Relation of Physical/Geological and Biological Parameters to Site Preparation

In their marsh restoration projects, Woodhouse et al. (1972) and Garbisch (1973) used relatively simple procedures. Site preparation consisted mostly of depositing substrate (dredge spoil or sand fill) in the area, grading it to the proper intertidal elevation, and planting. The sites were in protected areas, shielded from direct ocean currents and stress. As an added precaution, Garbisch erected a temporary groin around a portion of the marsh, but later determined it unnecessary. Broome et al. (1973) suggested that fertilization would be useful for establishing vegetation in some nutrient poor sites. The efficiency of a fertilizer will depend on (1) the nutrient requirement of the plants; and (2) the rate of uptake before the fertilizer is washed away by the tide.

Few conclusions can be drawn from the literature as to the anticipated site requirements of a marsh restoration project specifically in Maine. However, as discussed above, important considerations that should be investigated are (1) the effect of increased sedimentation in the early stages of development (as described by Chapman 1960); (2) the long term effect of sedimentation versus sea level rise; and (3) the acceptable

substrates that will (a) provide optimum drainages, (b) reduce destruction by ice, (c) resist erosion, and (d) provide sufficient nutrition, or be able to absorb nutrients for plant utilization.

Economic Parameters

Cost/benefit evaluations are often extremely important factors in the implementation of a technical project such as tidal marsh restoration. The situation is very complex, mostly because of the new and incompletely developed techniques involved in restoration, and the abstract nature of salt marsh "benefits." A strict cost/benefit analysis for salt marsh restoration would be most difficult because of the complexity of relating specific costs to benefits, which are realized only remotely from the initial expenditure. Hence, no tabular equation will be presented here. Instead a relative comparison between reported values and marsh building cost considerations will be discussed. The economic feasibility of salt marsh restoration in Maine depends on how the cost of building a marsh compares with the return to the builder, either as an aesthetic reward or a public service.

Value of a Salt Marsh

The cash value of salt marshes is nearly impossible to determine. Dollar figures for productivity of marshland and the consequent value of commercial fisheries have been given by Dow (1962, 1971), Johnson (1969), and others but these seem inadequate for total cost/benefit considerations.

Peoples (1971) prepared an excellent discussion on the value of tidal marshes in the northeast. In this work he listed the difficulties of measuring the value of marshes. These can be summarized in the following six points.

1. The benefits are mostly external (owners do not receive substantial return on their land).
2. There is a dislocation and delay between production and consumption (e.g., fish and waterfowl), and consumers don't see these "common property items" as the product of another

person's export.

3. Total value must be measured over the geologic period of the functioning of the marsh, with fluctuation in productivity and as a natural system over a long period of time.
4. All the benefits may not be recognized, and those that are may be seen only in terms of "benefits to man."
5. Many values are related to non-market items (e.g., aesthetic value of the experience of sport fishing).
6. The value of the marsh to society is not the difference between the value of the benefits minus the cost of acquisition.

Peoples' work has many applications in policy decisions and marsh management theory, but these will not be discussed here. The benefits identified by Peoples are listed in Table 1 along with the relative magnitude of the benefits.

Table 1. Benefits of Coastal Marshes and their Relative Magnitude (Peoples 1971) [with the author's interpretations]

Benefits	Relative Magnitude of Benefits
Marine sport fishing	Very large
Recreational shellfishing	Minor
Commercial fisheries	Moderate
Recreational trapping	Negligible [very large]
Commerical trapping	Negligible
Waterfowl hunting	Minor-Moderate [very large]
Bird watching, nature study, photographs	Moderate-Large
Endangered species	?
Environmental improvement	
Water pollution abatement	Minor [moderate]
Air pollution abatement	Negligible
Climate moderation	Negligible-Minor
Self-maintaining open space	Moderate-Large
Flood expansion zone	Minor-Moderate
Storm buffer	Negligible
Sediment trapping	Minor-Moderate
Erosion prevention	Minor-Moderate
Environmental education, research areas	Minor [moderate]

These benefits relate the natural function of the resource to "products" directly useful to people. As explained by Peoples, "Benefits are the link between the natural functions and values [of the marsh]." These benefits are rated in terms of the total function of a natural marsh. However, the only categories which are not significantly determined by Spartina alterniflora marsh land are trapping, climate moderation, flood expansion zone, and storm buffer. The majority of the benefits listed by Peoples can be considered benefits of an intertidal restoration marsh.

The benefits emphasized by Garbisch (1973) for his restoration marsh include high primary productivity (fisheries), soil stabilization (erosion prevention), waterfowl habitat (hunting), and pollution control. Reed and Moisan (1971) indicated heavy use of tidal marsh (St. Lawrence estuary) by nesting and migrating waterfowl.

In sum, there are many identifiable benefits of intertidal salt marsh in the northeast. An artificially established Spartina alterniflora marsh in Maine would embody most of the benefits of a natural marsh. These benefits would not flow back to the builder, however, and the marsh must be considered as a contribution to the "net social value" of all tidal marsh lands in the region.

Costs

The cost of a salt marsh restoration project would depend almost entirely upon how nearly the project fit the ideal site selection criteria (discussed below). Basic projected costs can be divided between the materials and labor (including equipment).

An important factor in creating a suitable site for a new intertidal marsh is an abundant source of fill material (e.g. dredge spoil) to build the area up to the proper elevation into the intertidal zone. If purchased by the yard, the cost of fill would be very expensive. The alternative is to utilize an area that is near a project producing waste fill, or where it would be economically sound to deposit fill in the new marsh area rather than some other area, e.g. offshore. Another possible source of fill might be offshore mining. This is a procedure that is currently being developed to insure an adequate supply of construction fill materials.

The application of marsh construction techniques should not be limited to dredge spoil disposal sites, however. Natural shorelines that are eroding or unstable would be prime targets for marsh cultivation.

The supply of plants for the new marsh would be another major expenditure. Woodhouse et al. (1972) found the most economical method for establishing marshes in North Carolina to be seed propagation. This may be very difficult in Maine because of a much shorter growing season. The variety of Spartina in Maine is adapted to this short season and experiments should be conducted to determine the rate of establishment of seedlings in Maine. Garbisch (personal communication) found propagation by seedlings (raised in a greenhouse from seed) to be very effective for rapid establishment. Environmental Concern, Inc., does supply a limited amount of plant material for small marsh projects at minimal cost. For larger scale marsh projects, green house space for culture of Spartina seedlings would be recommended.

Expenditures for other materials such as fertilizer and temporary bulk-heading equipment would depend entirely on the requirements of the indivi-dual marsh site. These items may be needed to insure the success of the new marsh if either natural nutrients or natural protection from waves and currents were less than ideal.

Projected labor costs include technical engineering skills as well as manual labor for filling and grading during site preparation. Manual labor would be required for the actual planting. Woodhouse et al. (1972) found the use of a mechanical planter helpful for planting Spartina alterni-flora seedlings. Garbisch (pers. comm.) planted seedlings (in various sized peat pots up to 6 inches in diameter) by hand very successfully. Cost for the mechanical planter may not be economical for a small project, but would pay for itself in reduced labor costs for a large marsh project.

Actual costs for marsh projects would depend on size of area and its suitability for restoration. Values for the cost would be most difficult to ascertain at this time. Initial estimates, however, indicate that a marsh project might cost in the range of several hundred to several thousand dollars per acre. A carefully drawn hypothetical model will be needed before an accurate cost analysis can be formulated.

Site Selection Criteria

As a summary, the following criteria represent the most important factors that should be considered in choosing a site for a salt marsh restoration project in Maine. These are not rigid criteria, for limitations can generally be overcome by either money or engineering manipulation. However, the more closely an area fits the criteria the more successful and economical the project will be.

For building an intertidal marsh the area should be

1. A broad shallow water region that can be filled to the intertidal range of Spartina alterniflora or subtidal range of Zostera marina.
2. Near an economical and ecologically viable source of fill (dredging, road cut, etc.).
3. In a sufficiently protected area to minimize artificial bulkheading and insure long life of the new marsh (erosion, sedimentation, etc.).

For an individual marsh

1. The size should be determined in relation to
   a. the area available for fill
   b. the amount of fill available
2. The engineering of the marsh should account for
   a. the optimum slope (considering area and type of substrate
   b. the natural stability and drainage of the substrate
3. Viability should be rated in terms of
   a. natural physical protection and protectability
   b. natural fertility and artificial fertilization needs
   c. possible effect of ice scouring

These preliminary criteria should be expanded and refined as discussion for Maine salt marsh restoration/relocation continues. They will be critical in determining potential marsh sites and evaluating project feasibility in relation to the objectives of the Maine Department of Transportation.

LITERATURE CITED

Adams, D. A. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44:445-456.

Batchelder, C. H. 1926. An ecological study of a brackish water stream. Ecology 7:55-71.

Bourn, W. S. and C. Cottam. 1950. Some biological effects of ditching tide water marshes. Res. Rpt. 19. Fish & Wildlife Service, U.S.D.I.

Broome, S. W., W. W. Woodhouse, & E. D. Seneca. 1973. An investigation of propagation and the mineral nutrition of *Spartina alterniflora.* U. North Carolina Sea Grant Program Publ. UNC-SG-73-14. 121 p.

Buckman, H. O. and N. C. Brady. 1969. *The Nature and Properties of Soils* (7th ed.) The MacMillan Co. New York. 653 p.

Burkholder, P. R. and T. E. Doheny. 1968. The biology of eel grass. Publication of Dept. Conserv. Waterways, Town of Hempstead, Long Is., N.Y. 120 p.

Chapman, V. J. 1960. *Salt Marshes and Salt Deserts of the World.* Interscience Publishers, New York. 392 p.

Colby, B. R. 1963. Fluvial sediments - a summary of source, transportation, deposition, and measurement of sediment discharge. U. S. Geol. Survey Bull. 1181-A. 47 p.

Cooper, A. W. 1969. Salt marshes. *In* H. T. Odum, B. J. Copeland, and E. Q. McMahan (eds) Coastal Ecological Systems of the United States Vol. 1, Report to the Water Pollution Control Administration, Washington, D. C. p. 563-611.

Davis, R. B. 1956. An ecological study of a tidal salt marsh and estuary. M.S. Thesis. U. of New Hampshire. Durham, N.H. 102 p.

Dow, R. L. 1962. Maine's coastal marshlands--their values, present and future. Me. Dept. Sea & Shore Fishreis, Augusta, mimeo rpt.

______, 1971. Commercial value of marine species in estuaries. Unpublished proceedings of the Maine Salt Marsh Conference, Bowdoin College, No.c 1971.

Farrell, S. C. 1970. Sediment distribution and hydrodynamics, Saco River and Scarboro estuaries, Me. U. Mass. Dept. Geol. Contr. GCRG.

Garbisch, E. W., Jr. 1973. Green grow the rushes: Tidal marsh synthesis in the Cheasapeake Bay. Potomac Appalachian Magazine No. 1 (Spring 1973).

Garbisch, E. W. Personal communication 1973. Environmental Concern, Inc. P. O. Box P., St. Michaels, Maryland.

Johnson, D. W. 1925. The New England Acadian Shoreline. Wiley & Sons. New York. 608 p.

Johnson, Peter L. 1969. Wetlands Preservation. Open Space Institute, 145 E. 52nd St., N.Y. 10022.

Miller, W. R. and F. E. Egler, 1950. Vegetation of the Wequequock Pawcatuck tidal marshes. Conn. Ecol. Monog. 20(2): 143-172.

Mooring, M., A. W. Cooper, and E. D. Seneca. 1971. Seed germination response and evidence for height ecophenes in Spartina alterniflora from North Carolina. Amer. J. Bot. 58:48-55.

Peoples, Robert A., Jr. 1971. The northeast's coastal wetlands: Values and their policy implications. Thesis (M.S.) MIT Dept. Political Science, Cambridge, Mass.

Pomeroy, L. R. 1959. Algal productivity of salt marshes of Georgia. Limnol. & Oceanogr. 4:386-397.

Redfield, Alfred C. 1972. Development of a New England salt marsh. Ecol. Monographs 42(2)201-237.

Reed, Austin, and Gastan Moisan. 1971. The Spartina tidal marshes of the St. Lawrence estuary and their importance to aquatic birds. Nat. Can. 98(5):905-922.

Shea, M. L., R. S. Warren, and W. A. Neiring. 1972. The ecotype/ecophene status of varying height forms of Spartina alterniflora. Bull. Ecol. Soc. Amer. 53(2):15-16. (Abstract)

Smalley, A. E. 1959. The growth cycle of Spartina and its relation to the insect populations of the marsh. In Proc. Salt Marsh Conf, Athens. Georgia. p. 96-100.

Stalter, Richard and W. T. Batson. 1969. Transplantation of salt marsh vegetation, Georgetown, N. C. Ecology 50(6):1087-1089.

Teal, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecol. 43(4):614-624.

Teal, J. and M. Teal. 1969. Life and Death of a Salt Marsh. Audubon Ballantine, New York.

Terry, Orville, Personal communication 1973. Marine Sciences Resource Center, SUNY, Stony Brook, Stony Brook, New York.

Thompson, Stewart N. 1973. Sea-level rise along the Maine coast during the last 3,000 years. Thesis (M.S.) Univ. of Maine at Orono Graduate School Dept. Geol. Sciences.

Udell, H. F., J. Zarudsky, T. E. Doheny, and P. R. Burkholder. 1969. Productivity and nutrient values of plants growing in the salt marshes of the Town of Hempstead, Long Island. Bull. Torrey Bot. Club 96(1):42-51.

Weymouth, Terry. Personal communication 1973. Div. Environmental Protection, S. D. Warren Co., Westbrook, Maine.

Woodhouse, W. W. Jr., E. D. Seneca, and S. W. Broome. 1972. Marsh building with dredge spoil in North Carolina. Agricultural Experiment Station, North Carolina State University (Raleigh) Bull. No. 445. July 1972.

workshop report

ABSTRACT

Results of a workshop held to discuss the feasibility of salt marsh restoration/ propogation in Maine are detailed. Opinions of marsh restoration experts from Maryland and North Carolina, after a field reconnaissance of the Maine coast, are presented, as well as the reactions of state, private, and institutional interests attending the workshop. Conclusions and recommendations of the workshop are presented. Briefly, it was concluded that artificial marsh establishment is feasible in Maine, but that prior to any large scale project, certain policy considerations ought to be clarified. Furthermore, it was felt that a pilot study ought to be designed to develop the appropriate technology and to determine the limitations of the procedure.

Introduction

This report is the second working report of the feasibility study on salt marsh restoration being conducted by Reed & D'Andrea for the Maine Department of Transportation. The first or Background Report (10/2/73) reviewed the literature concerning marsh restoration, the state of the art, and parameters of marsh growth and development.

On Saturday, October 6, 1973, several people knowledgeable about salt marshes in Maine and concerned with the future of the resource met at the Ira Darling Center of the University of Maine (Walpole) with Drs. W.W. Woodhouse and E. W. Garbisch, both leaders in the field of marsh restoration. At the workshop the potential for marsh restoration in Maine was discussed at length. In addition to the workshop itself, Garbisch and Woodhouse visited several marshes and reviewed coastal conditions in the field. They saw marshes between Portland and Rockland and saw examples of some potential marsh sites.

Several significant accomplishments resulted from the workshop and field reconnaissance:

1. Maine scientists and researchers were introduced to the state of the art and the techniques for marsh restoration.
2. Restoration experts, who worked almost exclusively with southern marshes (Maryland, North Carolina) were introduced to the Maine environment and the dynamics of northern marshes.
3. Marsh restoration was determined a desirable activity for Maine. There is much potential for securing the coastal system of Maine through protection of the marsh resource.
4. Procedural and strategic considerations were identified, notably the necessity of a pilot project and the opportunity for the involvement of several state conservation organizations.

It was concluded that salt marshes can be established on the coast of Maine and that the technical capability for doing so should be developed.

This report, then, will briefly describe the field trip of Woodhouse and Garbisch (10/5/73) and the workshop (10/6/73). These two events were instrumental for information gathering and will provide the background for the final recommendations of this study.

Field Reconnaissance

(10/5/73)

In the field both Woodhouse and Garbisch were introduced to Maine coastal marshes. The trip was made between Portland and Rockland with interim stops in Falmouth, Small Point (Phippsburg) and Wiscasset. The purpose was to see natural marshes and explore the types of conditions that exist in Maine so that a comparison could be made with marsh restoration sites in other areas.

In Falmouth, a vigorous _Spartina alterniflora_ marsh was observed at the mouth of the Presumpscot River. First year seedlings and the results of turf dislocation from ice action were evident. Seed production appeared to be heavy and conditions favorable for good marsh development.

Similar conditions were observed in Wiscasset and Rockland, although the marshes seen were much smaller. In Wiscasset a small marsh is actively expanding behind the railroad causeway near Clark Point. This is most likely a man-induced marsh caused by restriction of water flow and increased sedimentation. In Rockland Harbor small patches of _Spartina_ are growing in exposed sites in a poor gravel substrate. In a more sheltered area of the harbor, seedlings appeared to indicate potential marsh development.

On Small Point conditions of a well-developed high (_Spartina patens_) marsh were observed. This is a marsh of relatively low productivity which is partially due to the mosquito control channels dug throughout the marsh. These restrict water flow in the marsh and hence circulation.

It is evident from these observations that conditions such as seed production and marsh viability in Maine are not significantly different from

those of more southern marshes. From this Garbisch and Woodhouse concluded that marsh establishment is possible in Maine and that the workshop should focus on (1) the desirability of marsh restoration in Maine and (2) the most reasonable approach to developing the technology.

Restoration Workshop
(10/6/73)

The workshop was a day-long discussion meeting of several Maine researchers concerned with the future of the Maine coast and its marsh resources.

Those present were:

Richard Anderson	Maine Audubon Society
Dr. Edgar W. Garbisch	Environmental Concern, Inc. (St. Michaels, Maryland)
Michael Heath	Reed & D'Andrea
William Reed	Reed & D'Andrea
William Reid	Maine Department of Transportation Director, Environmental Services
Howard Spencer	Maine Dept. Inland Fisheries and Game
John Steenis	U.S. Fish and Wildlife Service
Brad Sterl	Maine Dept. Sea and Shore Fisheries
Dr. Orville Terry	SUNY, Stony Brook, New York
Terry Weymouth	S. D. Warren Co., (Westbrook)
Dr. W. W. Woodhouse	University of North Carolina (Raleigh)

Formal Presentations (morning session)

W. W. Woodhouse of North Carolina State University (Raleigh) reviewed the purposes, techniques, and results of his projects on the North Carolina coast. He presented a short description with slides of the several new marshes constructed in conjunction with the University, The Sea Grant Program, and the Army Corps of Engineers. Most of the marsh projects in North Carolina have centered around stabilization of dredge spoil, because of the extent of dredging operations for channel maintenance (for navigation) in the unstable sands of the region. As explained in the Background Paper (10/2/73) experiments begun in 1970 were carried out by Woodhouse and his staff with direct seeding and transplanting _Spartina alterniflora_. Woodhouse reported generally excellent success except in areas where there was heavy storm damage. Best results were obtained

using young (less than one year) transplants. Except where there was heavy storm damage, seeded areas were well established and transplants were reproductive after the first year.

On the North Carolina coast, the substrate has a high percentage of sand, with little silt or clay. Also due to the nature of engineering activity, dredge spoil is the most common material available for marsh restoration projects. In contrast, very little dredging is done in Maine and consequently marsh restoration projects in Maine should not depend on dredge spoil as a source of substrate.

Woodhouse has experimented with eroding shoreline stabilization techniques in North Carolina. Data from these experiments (as on Cedar Island, 1972-1973) will be valuable for adaptation to Maine conditions.

E. W. Garbisch (Environmental Concern, Inc., St. Michaels, Maryland), the other consulting authority for this project, described his activities in the Chesapeake Bay and nearby coastal areas. Garbisch has been involved with marsh restoration for over three years. He is experimenting with the techniques for efficient generation and regeneration of salt marshes through establishment of fourteen species of marsh plants.

Filling and planting new marsh lands may, in many instances, constitute altering wetlands and permits may be required in Maine. In the Hambleton Island project, a permit was secured from state authorities. In the permit, protective devices were required to guard against damage to the marsh and insure success of the project. Temporary bulkheads were erected to protect the new marsh from wave stress. These proved unnecessary, however, due to the rapid stabilization of the new marsh. Cost of this type of breakwater is about six dollars per linear foot. It may be effective in protecting a severely stressed site.

Garbisch has experimented with several different planting techniques. Work has been done to test cost and effectiveness of (1) seeding, (2) transplanting natural marsh seedlings, and (3) cultivated seedlings (peat pots). Costs ranged from about $600/acre for seeding to $1,200-$1,800/acre for peat pot transplants. Cost per unit of production was more favorable for

transplants because net production of the transplants is about three times that of the seeded sites during the first year.

Fertilization of new marshes was also found to greatly enhance growth and hence stabilization rate. Garbisch recommends fertilizing where erosion control is necessary because it encourages growth of the root systems which bind the substrate. Also, there is greater aerial mass to trap suspended particles.

The success of the Hambleton Island marsh was dramatically demonstrated after the year-old marsh was completely uprooted by foraging geese. Activity by geese and other animals in the Chesapeake Bay is common, but damage to the new marsh was severe. However, the following spring the marsh sprouted from seed which was distributed by the geese and natural regeneration was nearly uniform over the entire marsh.

Dr. Orville Terry, (SUNY, Stony Brook) described his marsh building project in Nassua County, Long Island. This project dealt with revegetation of disturbed marshlands where a sewer pipeline had been laid. The pipeline leads out to sea for offshore disposal of sewerage waste and runs through a large, well-developed marsh on the oceanside of Long Island. Terry and his associates relied mostly on seeds from North Carolina provided by Woodhouse at North Carolina State University. In addition, they used turf plugs obtained from the existing local marsh. The techniques used were unrefined but success is difficult to evaluate since this is only the end of the first growing season.

Woodhouse pointed out that plants native to North Carolina would most likely not grow well in such a distant location. He emphasized the variation between geographically separated colonies of Spartina.

Terry Weymouth (S. D. Warren Company, Westbrook) described his on-going project of eelgrass (Zostera marina) establishment in the Presumpscot River estuary. One purpose of this project is to reduce the hydrogen sulfide odors from the anaerobic decomposition of effluent on the mudflats which border the river. The project has been continuing for four years.

Weymouth described two methods: transplanting patches of turf (about 8 inches square) to new areas further up the estuary; and transplanting sprouts or individual rhizomes with a single aerial shoot. These were planted in rows with three feet of space.

Experiments were conducted to determine the elevation range of eelgrass and the most favorable growth conditions. Weymouth found that eelgrass grows best in the lower tidal range and spread radially with each patch of turf or rhizome at the focus.

The effectiveness of reducing hydrogen sulfide odors from the mudflats is questionable but such a positive action by the paper company is commendable. This is an activity and an approach which could be effectively combined with a marsh project on the Maine coast.

Discussion (afternoon session)

The afternoon session consisted of a group discussion of policy and problems associated with marsh restoration in Maine. The first issue discussed was the advisability of undertaking marsh restoration. It was pointed out that having the capability of generating marsh land must not suggest the destruction of another productive or potentially productive system. In other words, a productive clamflat should not be filled and used as a site for a new salt marsh. Similarly, a polluted flat which might be restored with improved water quality should not be altered without cause. Also, in developing the technology for salt marsh construction, the value of natural marsh must not be underestimated and it should be understood that marshes should not be destroyed even if their acreage can be replaced in another location.

The question also arose as to the objective of maintaining absolute acreage of marsh--whether the benefits of the marsh were to be maintained in a particular estuary or to be maintained for the good of the coastal system as a whole. It was the concensus of the group that, although the entire system should be kept in mind, productivity of a particular estuary should be the primary consideration in the maintenance or enhancement of marsh acreage.

It was also concluded that marsh sites should be located on sterile areas or otherwise unproductive areas. On the other hand, techniques could be developed so that if relatively unproductive clambeds were filled for a new marsh, extra fill could also be placed below the new marsh and reseeded with clams. This could possibly enhance commercial clam production as well as increase acreage of salt marsh.

Discussion then turned to the physical and biological considerations of marsh restoration. Garbisch pointed out that fresh substrate is often more conducive to marsh establishment than trying to vegetate old, undisturbed substrate. This is due to the exposure of nutrients which can be made available to the transplants.

Maine marshes often have layers of sand, peat, and clay which indicate different stages in their development (erosion/sedimentation cycles and sea level fluctations). Within broad limitations, the content of the substrate is not generally limiting to the development of a marsh because it acts mostly as an anchoring medium. On the other hand, Woodhouse indicated nutrient content of the substrate is extremely important. However, in Maine, this nutrient supply does not appear to be a major limiting factor because of the generally high organic content of the substrate.

Due to the nature of marsh as a sediment trap and nutrient reservoir, it is reasonable to assume that a salt marsh could help tie up nutrients from sewer effluent or other sources of concentrated nutrients and feed them back to the estuary at an even rate. It was suggested that a marsh might be created in conjunction with a sewerage treatment plant so that the impact of the effluent would not be an unbearable burden on the existing system.

Contrary to Garbisch's observation of heavy utilization of the marsh by wildlife (large animals), Skip Spencer noted very little destruction of marshes in Maine by foraging animals. He stated that use of marshes by large consumers is apparently confined to muskrats, crabs, and various waterfowl.

Discussion then turned to possible approaches to develop marsh technology. Many questions were asked that must be answered before a large commitment could be made by any project sponsor. These are questions that probably can be answered in a pilot project. The pilot project is necessary to get some basic facts about the problems which would be encountered in a larger scale Maine marsh project. The pilot project should determine:

1. The basic methodology and techniques for establishing new marshes.
2. Acceptable types of project sites
   a. Dredge spoil
   b. Eroding shoreline
   c. Natural intertidal areas where stress precludes natural vegetative establishment
3. Rate of establishment
4. Possible effects of ice (initial suggestions)
5. Range of planting conditions (elevation, season, fertilizing requirements, best species).

As mentioned, dredge spoil is not a necessary condition for marsh establishment in Maine. Woodhouse emphasized that a pilot project should be located in an area where the marsh would be beneficial. Garbisch suggested that the best experimental conditions would be to limit the variables to those which needed to be tested directly and that a low cost pilot project could be carried out on a natural shoreline which had sufficient tidal range to support Spartina alterniflora.

Several sites were then suggested for possible projects or pilot projects. Two dredging sites (Rockland and Scarboro) were discussed but determined undesirable because of the firm contracts already established. Brad Sterl suggested Mill Brook in Falmouth (near old Route 88). This is an area recently torn up by sewer line construction and would not require any fill. Possibilities exist in the Presumpscot River and Back Cove in Portland where some large marshes already exist and pollution reduces their potential as commercially productive areas. A severe problem exists in Back Cove because of the instability of the sediments and their proximity to a highway. A marsh could be very effective in stabilizing this area. In Yarmouth, where Cousins River intersects with Interstate 95, the existing marsh is in danger by an inadequate culvert and may be destroyed

by channelization and erosion due to water currents. (In a draft environmental impact statement, however, this problem has been discussed and corrective action proposed.) Long Creek, South Portland, has several feet of clay which has been deposited from road construction. This is another area which could be revegetated with marsh grasses. In past highway projects, roadsides have been filled and planted with upland vegetation. If marsh vegetation were planted in a situation like this, the results would be stabilized roadsides with a self-maintaining buffer.

Several contacts and collaborators were identified by the participants. These include state and private agencies that could provide either financial or personnel assistance to a pilot project. Each individual had a definite interest in continuing the restoration project to fruition. These include the Department of Transportation, Department of Sea and Shore Fisheries, Department of Inland Fisheries and Game, the University of Maine, The RCD Threshold to Maine Project, S. D. Warren Company, and The Research Institute of the Gulf of Maine (TRIGOM).

Summary and Conclusions

The Maine Salt Marsh Restoration Workshop provided the forum for discussing the feasibility, advisability, and procedure of developing marsh restoration technology for Maine. In addition, the field reconnaissance and workshop discussion illuminated many facts that were not discussed in the Background Report. Highlights of the workshop can be summarized in three categories: marsh characteristics, locational and budget considerations for marsh restoration, and suggestions for the pilot project.

Marsh Characteristics

1. Marshes in Maine are capable of reproducing by seed.
2. Good [natural] marsh growth is possible on gravelly, harsh substrate.
3. Modification by ice is apparent and should be considered an important factor.
4. Local varieties should be used for cultivation.
5. Although substrate type is not usually a limiting factor (except for providing stability), it is best to begin a marsh on freshly disturbed substrate.

6. Nutrient content is not usually a limiting factor in Maine, but some areas may require fertilization for best development.
7. Marsh land in a polluted estuary should help reduce pollution level.

Locational and Budget Considerations

1. New marshes should be located in otherwise unproductive areas.
2. Any legal complications to a restoration project should be investigated.
3. Policy should be developed to discourage any marsh destruction which is not absolutely essential, even if the restoration technology is developed.
4. Natural shoreline and flats should be considered as potential marsh sites as well as possible dredge spoil areas.
5. Cost estimates by Garbisch indicate that general costs for a small project could range from $600/acre for straight seeding (high risk) to $1,200/acre-$1,800/acre for peat pot transplants (lower risk).

Pilot Project

1. A pilot project is necessary to develop the technology and to determine the limitations and applications of marsh restoration before a large scale project is undertaken.
2. It could be designed as a low cost, experimental project involving many conservation groups and shared funding.
3. The experimental procedure should be developed for the pilot project and participants organized as soon as possible.

Both Woodhouse and Garbisch feel that marsh restoration in Maine is feasible and a pilot project is the next logical step to determine the practicality of the concept for Maine. The information exchanged at the workshop will form the basis of the recommendations for the pilot project.

The final report of this study will present the findings of Woodhouse and Garbisch, describe the options for the pilot project and a recommended format, and the recommended strategy for bringing the concept to fruition.

final recomendations report

ABSTRACT

The rationale and uncertainties of salt marsh restoration/propagation are discussed in detail, in view of the findings of previous reports (Background Report, October 2, 1973, and Workshop Report, December 12, 1973). The need for a pilot study is emphasized and a recommended structure for such a study detailed. Objectives are outlined, including the determination of (1) site requirements and limitations, (2) responses of different species to varying environmental conditions, (3) effects of variable biological and physical conditions, (4) the most successful and economical method(s) of planting, (5) effectiveness of the new marsh in terms of productivity and the stabilizing of substrates, and (6) the effect of the new marsh on the surrounding area. Finally, an operational outline detailing the tasks of the pilot study is included.

Introduction

The concept of salt marsh restoration has been thoroughly described in the Background Report and Workshop Report of this study. These reports describe marsh restoration projects that have been attempted on the eastern seaboard and some of the techniques that have been used. In addition, the reports investigate some of the conditions existing in Maine that may have a bearing on the success of a marsh project along the Maine coast.

Many factors have been found suitable for developing man-made marshes in Maine. One of the most important is the ample evidence of healthy natural marsh development. This indicates a good production of viable seed and suitable conditions for germination and growth. In short, most of the evidence suggests that salt marshes are a viable resource in the state of Maine, and given suitable conditions, they can be artificially propagated. With the technology that is currently being developed in the field of marsh restoration, it is most reasonable to assume that this is an activity that can be applied on the Maine coast.

The rationale for creating salt marshes artificially on the Maine coast has not been clearly developed. The value of natural marshes as the nutrient bank for the coastal ecosystem is well known. However, all the ramifications of creating marsh land artificially are not presently known. In evaluating the desirability of this procedure, the ecology of the natural system in its natural state should be clearly understood. Any man-induced alteration of the natural system is, in effect, a man-induced alteration of the environment. Maintaining the integrity of the natural system is an important environmental, aesthetic, and moral cause. Nature usually has a remarkable capability to maintain a steady state and to recover from severe shocks by rebuilding to the optimum level. Here the question arises as to how much help nature needs in rebuilding the marsh resource. Interference in the natural state by man is usually designed for short term benefits which serve man's interest. Indeed, interference by man which is beneficial over the long term is rare in modern technology. The fact remains that modern technology and

modern society exist, and as a result, alteration of the natural environment does take place regularly. Coastal marshes are being destroyed, and rarely, if ever, are they allowed to colonize a new area that might naturally become suitable for salt marsh growth. The aim of much environmental-oriented technology currently being developed is to minimize the impact of man's activities and alterations of the environment.

This is the framework in which salt marsh restoration must be approached. Restoration technology is more or less a remedial step that we can use to reduce the impact of man's development. Specifically, restoration technology is being developed to:

1. Counterbalance losses of marshes.
2. Stabilize erosion (protect man's property, perhaps after natural protection was removed).
3. Stabilize dredge spoil (by-product of man's navigational needs).
4. Reclaim specific marshes or shorelines that have been altered.

The fact remains, though, that salt marsh restoration is a new technological development. As such, the technology should be evaluated in terms of how it might affect the natural balance of the salt marsh/estuarine system as it currently exists (if indeed previous interference has not already altered the natural balance beyond the point of no return). The positive impact of the new marshes should be evaluated in relation to the projected negative impact.

Unfortunately, this is an extremely complex issue with few established parameters or data. Negative impact of marsh technology <u>seems to be</u> minimal. However, considering the variation of coastal areas, and the extreme variation of Maine's coast in particular, each marsh project will be an individual effort with unique problems and opportunities. Baseline data for the Maine situation should be developed to facilitate the evaluation of each potential site. An efficient experimental program will be necessary to identify as many different physical circumstances as possible. This will insure good project design and minimize the risk in each marsh project. Usable data can be gained through a pilot program. Based on this data, each project site should be thoroughly investigated and an impact statement prepared before the project is initiated.

The expanding role of the Maine Department of Transportation in new areas of transportation and services opens possibilities for involvement in many aspects of salt marsh restoration. Examples include dredge spoil stabilization, shoreline stabilization, scenic right-of-way maintenance, flood control, and restoration of altered coastal ways. For the Department of Transportation this is also a positive approach to the conservation of ecosystems. This should be a major concern throughout the entire state in all sectors. Furthermore, use of marsh restoration technology need not be restricted to the Department of Transportation. Many state agencies and private conservation groups may find the techniques of restoration applicable to their own particular problems and projects. This project could be even more valuable for them if they are directly involved with the pilot project.

Given that salt marsh restoration is "feasible" in Maine (see reports by Garbisch and Woodhouse in the appendix), the task of defining the specific limitations of marsh construction for Maine remains. As mentioned, many of these limitations can be identified and quantified through a pilot project testing program. The recommended structure of the pilot program is detailed in this report following the summary of findings and recommendations.

Summary of Findings and Recommendations

The overwhelming evidence of this study indicates that it is possible to grow salt marshes on the Maine coast. Considering the technology that has been developed elsewhere and the natural viability of Maine marshes, there is every reason to believe that marshes can be cultivated successfully in Maine. We have determined that a pilot project should be conducted in order to define the exact technology that will provide the best results in a particular location, and to further explore the applicability of the restoration process.

From the feasibility study, it is shown that Spartina alterniflora can doubtless be established, and this species is the most productive component of the ecosystem. However, the ultimate applicability of marsh restoration lies in the ability to apply the technology to a number of problems. For

this reason, the capability of marsh restoration should be determined for many species, for example, the several groups that Garbisch has experimented with in the Chesapeake Bay. Garbisch has been successful in saline, brackish, and fresh water vegetative establishment. He has had good results with Spartina alterniflora, Spartina patens, Spartina cynosuroides, Distichlis spicata, Panicum communis, Panicum virgatum, and Ammophila breviligulata in salt to brackish water; and Scirpus americanus and Spartina alterniflora seedlings in fresh water (Garbisch et al., 1973.) If these other species can be successfully cultivated, the technology that is developed in the pilot project may be more widely applicable and valuable to the Maine environment.

Spartina alterniflora has been proven the most productive marsh species and, therefore, is potentially the most important component of the marsh ecosystem. Any cultivated marsh should serve two functions: solve the immediate problem (erosion control, substrate stabilization, etc.) and enhance the productivity of the ecosystem as a whole (or be otherwise helpful to the natural system). A species of high productivity would meet these requirements, as would species that attract waterfowl or provide cover.

The use of native populations or local stock has been found desirable in marsh construction projects. There is wide intraspecies variation from location to location and selected strains of many species have naturally developed along different areas of the coast. This condition will be important to remember when gathering seed and preparing plant stock for any particular marsh project.

Several cultivation techniques have been developed for marsh restoration. The applicability and limitations of direct seeding, root cuttings, transplanting, plugs, and peat pot seedlings should be thoroughly explored in the pilot project. It has been found that, although substrate type may not be a severely limiting factor in Maine, growth will probably be best if the substrate has been mixed or disturbed before planting, thus making nutrients in the substrate more available. Similarly, nutrient content will most likely not limit marsh development in Maine, but fertilization may be necessary for rapid establishment in areas, subject to severe stress (high wind or wave action, for instance).

As stated in the introduction, any project that interferes with the natural development of a region should be thoroughly investigated to determine possible influences on surrounding areas and the entire unit before the project is undertaken. The goals and rationale, then, should be clearly defined at the outset of a marsh restoration project. This makes both environmental and economic sense. A reasonable degree of success should be projected for a particular site from initial research before the project is undertaken.

Estimates of marsh expenses range from $600 to $1,800 per acre. This includes basic site preparation, planting, and maintenance. However, it does not include environmental monitoring which should take place in a marsh site, especially for such a new technology. The recommended pilot project is designed to answer many questions concerning applications and limitations of existing techniques and will undoubtedly add to the basic store of restoration technology. However, subsequent projects will also provide valuable information for future marsh restoration projects in the northeast.

Pilot Project

Objectives and Organization

A pilot project is being recommended in this study as the primary mechanism for determining the best procedure and techniques, and to reduce the risk in a full scale marsh restoration project. The pilot project, recommended by the participants of the workshop, is also considered essential by consultants Woodhouse and Garbisch. The pilot project will be designed to determine:

1. Site requirements and limitations
2. Response of different species to varying environmental conditions
3. Effect of various biological and physical conditions
4. Most successful and economical method(s) of planting
5. Effectiveness of the new marsh in:
   a. Productivity
   b. Stabilizing substrates
6. Effect of the new marsh on the surrounding area.

The object of a pilot project is to get a maximum amount of information with a minimum amount of time and energy. To accomplish this, there is an optimum for each level of the experimental design, i.e., many different variables can be tested in the same experiment or plot. The recommended experimental procedure is outlined below.

The approach being recommended for the pilot project is to establish several experimental plots in at least two different locations. The variation in locality should provide enough of a variation in geophysical and biochemical conditions so that a wide variety of parameters of marsh restoration can be tested. Variables that can be tested in the pilot projects are the effect of different substrate types, seeding vs. transplants of various forms, time of planting, elevation range, response to fertilizer, response to various salinities and pollution levels, and the effectiveness of different species in different areas.

The pilot project will also serve as a forum for integrating institutional and governmental research interests towards a common goal--that of salt marsh resource conservation. This coordination can take place (a) within state government (Department of Transportation, Department Inland Fisheries & Game, Department Sea & Shore Fisheries, Department of Conservation, Department of Environmental Protection) and (b) between state government agencies and research institutions (University of Maine, TRIGOM, Maine Audubon Society, and others). It is important that, since each faction has an interest in the resource, each should be allowed input into the pilot project so that maximum benefits can be obtained.

At this point, a financial commitment is necessary before a pilot project can be initiated. As recommended below, the pilot project should continue for 18 months, or at least two growing seasons and be in the realm of a $10,000 project. It is possible that the project be funded jointly by interested groups. But in any case, the several interested groups should be brought together in a consortium for the finalization of an experimental program that will be most beneficial to all. The Department of Transportation currently has the largest investment in the program and is the logical focus of the consortium. Hopefully, organization can be achieved within the existing structure of the institutions and so mobilization of the consortium should be a relatively easy process.

Initiation of the pilot project itself can proceed in either of two different time frames. Ideally, the full experimental procedure should be initiated as soon as possible. However, sufficient seed stock is not currently available for an adequate experimental program. Therefore, the pilot project can be (a) initiated as a partial program the first season determining site location and using local stock (seedlings and plugs) or (b) organized during this growing season, determining site and collecting seed so that the entire project can be planted for the next growing season (Spring, 1975). This is a decision that should be made by the consortium.

OPERATIONAL OUTLINE

I. Site Selection
   A. Type of site - characteristics
      1. Two or more locations
      2. Several different substrate types
      3. Different salinities
      4. Exposure varied but not too severe
      5. Size - 1/2 acre planted, 1/2 acre control for each site
   B. Location
      1. Suitable to carry out experiments and provide enough data
      2. In need of restoration, stabilization (established marsh to serve constructive purpose)
      3. Acceptable to the local citizenry and to regulatory agencies

II. Site preparation and baseline data
   A. Timing--so that planting can begin after ice-out or after threat of severe erosion
   B. Filling and grading (if necessary) or mixing natural substrate to make nutrients available
      1. Fill from spoil or inland
      2. Grade to as broad an area as possible from mean low water (MLW) to mean high water (MHW)
      3. Rototill on natural areas
   C. Initial Survey
      1. Elevation profiles and permanent benchmark

2. Chemical analysis

   a. Soils (nutrient content, organic matter, pH contaminants)

   b. Salinity in different parts of site

   c. General water quality

3. Physical analysis of substrate

4. Series of photograph records begun

III. Plant stock preparation

A. Species for experimentation

1. Spartina alterniflora between MLW and MHW
2. Spartina patens - MHW
3. Distichlis spicata - above MHW
4. Brackish and fresh water species could be tried if possible Ammophila breviligulata, Scirpus americanus, and Typha latifolia

B. Stock sources

1. Local varieties recommended - collected from nearby marshes
2. Limited quantities from other areas for comparison (Md., N.C., N.Y., or as available)

C. Seed collection - preceding fall (store as recommended by Broome et al, 1973)

D. Seedling germination--selected quantity of seed for peat pot seedlings

1. Time so that 2-month and 3- to 4-month seedlings are available at planting time
2. Grow in greenhouse situation with regular fertilizing program (techniques developed by Environmental Concern, Inc.)

E. Natural seedling collection

1. Collect young plants from nearby marshes (yearlings are best)
2. Time--shortly before transplant to site

F. Soil plugs from natural marsh - same as E.

IV. Planting

A. Design layout (modify to fit site characteristics)

1. Seeding - broadcast over area
2. Transplants--in rows perpendicular to slope--about 3' x 3' grid
3. Combine variables in different plots of each site - species, stock forms, planting date, fertilizing, etc.

habitat), environmental improvement (flood control, water quality improvement, others), erosion control and sediment trapping, environmental education, and nature study.

The people of the State of Maine will greatly benefit from the salt marsh restoration technology to be developed in Maine. It may also provide the positive impetus needed to unify the polarized conservation-minded organizations in the state. If the pilot project is carried out under the auspices of a consortium of Maine agencies and organizations, this unification can be initiated.

FINAL BIBLIOGRAPHY

Adams, D. A. 1963. Factors influencing vascular plant zonation in North Carolina salt marshes. Ecology 44:445-456.

Blum, J. L. 1963. Interactions between certain salt marsh algae and angiosperm. Bull. Ecol. Soc. Amer. 44:92

Blum, J. L. 1968. Salt marsh Spartinas and associated algae. Ecol. Monog. 38:199-220.

Broome, Stephen W. 1972. Seedling response to photoperiod and temperature by smooth cordgrass *Spartina alterniflora*, from Oregon Inlet, North Carolina. Chesapeake Sci. 13(3):212-215.

Broome, S. W., W. W. Woodhouse, E. D. Seneca. 1973. An investigation of propagation and the mineral nutrition of *Spartina alterniflora*. Univ. North Carolina Sea Grant Program Publ. UNC-SG-73-14. 121 p.

Burkholder, P. R. and T. E. Doheny. 1968. The biology of eelgrass. Publication of Dept. Conserv. Waterways, Town of Hempstead, Long Island, N.Y. 120 p.

Carnenga, J. 1973. Hunting a severn site to build a new marsh. Evening Capital (Annapolis, Md.) March 1, 1973.

Chapman, V. J. 1938. Studies in salt marsh ecology, sec. I, II, III. J. Ecology 26(1) 144-179.

Chapman, V. J. 1940. Studies in salt marsh ecology sect. VI and VII. Comparison with marshes on the east coast of North America. J. Ecology 28:118-152.

Chapman, V. J. 1940. Succession on the New England salt marshes. Ecology 21:279-282.

Chapman, V. J. 1960. *Salt Marshes and Salt Deserts of the World*. Interscience Publishers, N.Y. 392 p.

Cooper, A. W. 1969. Salt marshes. *In* H. T. Odum, B. J. Copeland, and E. A. McMahan (eds). Coastal Ecological Systems of the United States, Vol. 1. Report to the Water Pollution Control Administration, Washington, D. C. p. 563-611.

Davis, R. B. 1956. An ecological study of a tidal salt marsh and estuary. M.S. Thesis. University of New Hampshire, Durham, N.H. 102 p.

Dow, R. L. 1962. Maine's coastal marshlands--their values, present and future. Me. Dept. Sea & Shore Fisheries, Augusta, mimeo rpt.

Dow, R. L. 1966. Economic yield of some Maine coastal wetlands. Me. Dept. Sea & Shore Fisheries, Augusta, mimeo rpt.

Environmental Concern, Inc. 1973. Enhancing environmental quality. Tidewater Times 17(9) Feb. 1973. [Easton, Md.]

Farrell, S. C. 1970. Sediment distribution and hydrodynamics, Saco River and Scarboro estuaries, Maine. Univ. Mass. Dept. Geol. Contr. 6CRG.

Ferrigno, F., L. G. MacNamara, and D. M. Jobbins. 1969. Ecological approach to improved management of coastal meadow lands. Proc. 59th Annual Meeting N. J. Mosquito Control Assoc.

Garbisch, E. W. Jr. 1973. Green grow the rushes: Tidal marsh synthesis in Chesapeake Bay. Potomac Appalachian Magazine No. 1 (Spring 1973).

Garbisch, E. W. Jr., P. B. Woller, W. J. Bostian, and R. J. McCallum. 1973. Biotic techniques for shore stabilization. Paper presented at the Second International Estuarine Research Conference, Myrtle Beach, S. C. Oct. 15-18, 1973. (Avail. at Environmental Concern, Inc., P. O. Box P, St. Michaels, Md. 21663)

Hinde, H. P. 1954. The vertical distribution of salt marsh phanerogams in relation to tidal levels. Ecological Monographs 24(2):209-225.

Kuenzler, E. J., A. F. Chestnut, and C. M. Weiss. 1973. The structure and functioning of brackish water ecosystems receiving treated sewage effluent III, 1971-72. Univ. North Carolina Sea Grant Program Publ. UNC-SG-73-10.

Larimer, E. J. 1968. An investigation of possibilities for creating salt marsh in the estuaries of the Atlantic and Gulf Coasts. *In* Webb, J. W. (ed). Proceedings of the 22nd Conference of Southeastern Assoc. of Game & Fish Commissioners. p. 82-88.

Matthessen, George C. 1970. Tidemarshes: A vanishing resource. Mass. Audubon Society, Lincoln, Massachusetts.

McAtee, W. L. 1939. Wildlife of the Atlantic coast salt marshes. U.S.D.A. Circ. No. 520. 28 p.

Miller, W. R. and F. E. Egler. 1950. Vegetation of the Wequequock Pawcatuck tidal marshes, Conn. Ecol. Monog. 20(2): 143-172.

Mooring, M., A. W. Cooper, and E. D. Seneca. 1971. Seed germination response and evidence for height ecophenes in *Spartina alterniflora* from North Carolina. Amer. J. Bot. 58:48-55.

Odum, E. P. 1961. The role of tidal marshes in estuarine production. New York St. Conserv. 15(6):12-15, 35.

Peoples, Robert A., Jr. 1971. The northeast's coastal wetlands: Values and their policy implications. Thesis (M.S.) MIT Dept. Political Science, Cambridge, Mass.

Postma, H. 1967. Sediment transport and sedimentation in the estuarine environment. *In* Estuaries, G. H. Lauf (ed) Publ. Am. Assoc. Advmt. Sci., 83:158-179.

Redfield, Alfred C. 1972. Development of a New England salt marsh. Ecol. Monographs 42(2) 201-237.

Reese, K. M. 1973. Busy year ahead for tidal marsh makers. Chemical and Engineering News, March 12, 1973.

Rudloe, Jack. 1973. The greening of the new marshes. Passages 4(2) Feb. 1973.

Seiden, M. J. 1973. Scientists grow new wetland. The Sun (Baltimore, Md.) Jan. 25, 1973.

Sherman, E. A. 1968. Toward saving Maine's salt marshes. Maine Fish and Game, Winter 1968.

Stalter, Richard and W. T. Batson. 1969. Transplantation of salt marsh vegetation, Georgetown, N. C. Ecology 50(6): 1087-1089.

Sterl, Bradford. 1971. Destruction of Maine's salt marshes and estuaries. Unpublished Proceedings of the Maine Salt Marsh Conference, Bowdoin College, Nov. 6, 1971.

Teal, J. M. 1962. Energy flow in the salt marsh ecosystem of Georgia. Ecol. 43(4):614-624.

Teal, J.M. and J. W. Kanwisher. 1970. Total energy balance in salt marsh grasses. Ecology 51(4):690-695.

Teal, J. and M. Teal. 1969. *Life and Death of a Salt Marsh*. Audubon Ballantine, New York.

Thompson, Stewart N. 1973. Sea-level rise along the Maine coast during the last 3000 years. Thesis (M.S.) University of Maine at Orono Graduate School Dept. Geol. Sciences.

Webber, E. E. 1968. Seasonal occurrence and ecology of salt marsh phanerogams at Ipswich, Mass. Rhodora 70:442-450.

Webster, B. 1972. Marine scientists succeed in growing salt marsh in only seven months. New York Times. Nov. 23, 1972.

Woodhouse, W. W. Jr., E. D. Seneca, and S. W. Broome. 1972. Marsh building with dredge spoil in North Carolina. Agricultural Experiment Station, North Carolina State University (Raleigh) Bull. No. 445. July 1972.

appendix A

CONSULTANT REPORT ON MAINE'S SALT MARSH RESTORATION PROJECT

BY W. W. WOODHOUSE, Jr.
NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NORTH CAROLINA

REPORT ON SALT MARSH RESTORATION PROJECT

STATE OF MAINE

to

Reed & D'Andrea

by

W. W. Woodhouse, Jr.

General

On the field trip in the vicinity of Portland, Falmouth, Wiscasset, Rockland, and Small Point on October 5, 1973, we observed several areas in which *Spartina alterniflora* was expanding vegetatively into unoccupied surfaces. We also saw a limited number of seedling plants, occurring mostly in bare sites resulting from ice action. Seedheads were quite plentiful and there appeared to be a rather heavy seed crop in several areas. Based on these observations, discussions with the people attending the workshop on October 6, and our experiences elsewhere, I am confident that salt marsh can be established on suitable sites along the Coast of Maine. Furthermore, it seems to me that it would be desirable to develop the capability of doing this in order to be in position to make the best use of sites and situations as they develop in the future.

Recommendations

There is little doubt that the overall techniques of marsh establishment that have already been developed elsewhere along the Atlantic Coast can be used here. However, this involves transporting these methods some considerable distances in terms of such things as climate, tides, substrates, sedimentation, and particularly the indigenous strains of *S. alterniflora*. Consequently, some selection and adaptation of techniques will be required before the most practical

approach can be defined. I feel that this can best be done through the conduct of some sort of pilot project in which the several alternative methods are tested under Maine conditions and some feel obtained for what can be done and where.

Sites

I visualize that this would involve plantings on two or more sites, selected in close consultation with persons who are knowledgeable of local estuarine biology and dynamics (several of those in attendance on October 6 could be very helpful). These sites should be in areas where it can be generally agreed that marsh establishment would be desirable and where wave action and currents would be likely to be such as to offer a reasonable chance of success. If possible, more than one kind of substrate should be included.

The use of dredge spoil to create usable sites, such as has been done elsewhere, would be fine if the opportunity arises, but this is by no means essential. In fact, it appears that tests not involving spoil might yield the most immediately usable results in view of the rather limited extent and nature of dredging activity in Maine.

Size of the planting site is not important except that it should be large enough to be effective in demonstrating the project to the public. Also, some minimum size is needed to enable the planting to protect itself from waves, currents, etc. Probably 1/2 acre is about as small as one should consider planting on any one site.

Seeds

Assuming that such a project might be initiated in time to utilize the 1974 growing season it will be vitally important to collect a supply of seeds from local marshes immediately. Most seedheads I observed are mature, some have already shattered, and most of the remainder will be gone soon. These can

be stripped from the heads by hand or stored on the heads. Do not let them dry out! Store at 34^{o}-36^{o} F in sea water or water to which salt has been added.

It would be desirable to keep seeds from distinctively different locations separate for later comparison.

Local seed are, I think, vital to the project at this stage in light of our experience with plants grown from seeds of S. alterniflora collected throughout much of its range along the Atlantic and Gulf Coasts. Types, adapted to specific combinations of the various factors, have evolved at many locations and, although some are much more versatile in their adaptation than others, this is not predictable until they have been grown for some time in the new environment, Therefore, it is wise to stay with local sources for projects such as this, using other seeds for comparison only.

Seed Utilization

A part of the seed should be used to produce planting stock by the greenhouse (peat pot method). This is the more expensive way but very likely the least risky approach and makes maximum use of a limited seed supply. I would think the best bet initially would be to contract with Environmental Concern to produce these plants for you, using your seed.

Some seeds should be reserved for direct seeding tests. This may not have as much promise under Maine conditions as further south due to the shorter growing season. On the other hand, the vigor of this species that is evident on some Maine marshes indicates to me that it should not be ruled out. Seeds of the more southern types will germinate at temperatures just above freezing and the local strains may grow off and establish quite well.

Other Plants

If possible, plantings should include plants dug locally from existing

stands. These should come from young, open stands, or along margins, where plants are less crowded and more vigorous.

The inclusion of plants from other sources - Maryland, North Carolina - would be of value if time and space permit. We would be glad to supply some seeds for this purpose.

Test Layout

This will have to be fitted to the site. In general it is best to extend any given treatment up and down the slope - plants over most of the tide range, seeds over the upper 1/2 of the tide range. This gives a quick answer on the elevation range over which planting is feasible. Replications of the different treatments (types of plants, seeds, planting dates, etc.) within each site improves comparisons and reduces risk of complete loss by erosion, ice, etc.

Planting

Suggest planting in rows, usually perpendicular to the slope, spaced 3 x 3 ft. This would apply to both peat pot and bare root plants (procedures detailed in Bull. 345).

Seeding

Broadcast seed by hand after mixing enough dry sand to cause them to separate. Area can be furrowed before seeding and raked afterward. The object is to cover seeds 1/2-3 inches deep. A small garden-type rototiller works well on many sites. Determine germination of seed lots before hand and sow 100 viable seeds/M^2.

Date of Planting

This is not critical in the case of transplanting but it would be well to try more than one. I suggest a date about 2 weeks prior to corn planting time in the immediate vicinity as the first date. A second date could be 2 or 4 weeks later.

Seeding could be done at the first planting date with some seed reserved in case erosion removes too much of the seeding.

Data Collection

As a minimum I would suggest the following:

1. Substrate - sample upper 6 inches and analyze for nutrient content, organic matter, and pH. State or private soil testing service can do this. Also particle size (sand, silt, clay) should be done at the beginning.

2. Establish elevations by survey.

3. Follow development of planting through frequent inspection (every week or so) and record progress and any occurance that may affect it. Photos are quite useful in charting stand development.

4. Measure above-ground dry matter production, number of stems/unit area, and mean stem height near end of growing season on all treatments. Root and rhizome samples may also be of interest.

5. Percent survival.

6. Relate stand and growth to elevation.

7. Check for evidence of sediment accumulation and measure if it appears worthwhile.

Biological monitoring of all sites would be interesting, but I do not consider it essential in this case. It can be laborious and expensive, and is not likely to have great value. It has already been established elsewhere that a planted stand of S. alterniflora rather rapidly approaches the biological activity of a natural marsh, growing under the same conditions. The probability of a planting in Maine behaving differently is not very high. Of course, if someone competent to do so should become interested enough to follow up on this aspect, that would be fine.

Duration

I feel that with reasonable luck a great deal could be learned in one year. However, I believe it would be a mistake to stop that soon. None of

the plantings are likely to develop into a full stand under 13-15 months. Therefore I would recommend that a pilot project of this sort cover at least 18 months and that provision be made for some follow-up on successful plantings after that.

Budget

I'm afraid anything I say at this stage is a guess, and not a very good one at that. Costs will vary a great deal, depending on number and size of sites, their locations, and particularly the sources of the manpower that will be required to do the substantial amount of manual labor involved. As a start, I would think that a total of $5,000 to $8,000 would be a reasonable estimate for the kind of project I visualize; not much less than the latter sum if it is to cover an 18-months period.

appendix B

CONSULTANT REPORT ON MAINE'S SALT MARSH RESTORATION PROJECT

BY EDGAR W. GARBISCH, Jr.
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ST. MICHAELS, MARYLAND

Environmental Concern Inc.

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Mr. Michael C. Heath
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Dear Mike:

Having just returned from an estuarine research conference in South Carolina, I thought that I would set down some of my thoughts on your workshop before any further delay.

The two noteworthy conclusions of the workshop are that (1) tidal marsh relocation and restoration in Maine is feasible and (2) a small pilot project should be undertaken for the purpose of identifying the methodologies applicable for marsh establishment in Maine. It was apparent from the discussion that such a pilot project could be activated with least delay if the project site or sites would consist of natural unvegetated intertidal shores in the area.

In order to assure the maximum of practical informational output from a pilot project, the following recommendations are made for your consideration.

I. Natural Shore Pilot Marsh Establishment Project Site Requirements.

(a) Select two or more natural shore areas that total not more than one acre and that are not subject to extensive exposure. Approximately 50% of the total area selected should be designated as control area and the balance be subject to a program of vegetative establishment.

(b) The tidal elevational range of the areas should extend from MLW to MHW or above.

(c) It would be desirable for the substrate of the two or more shore areas to differ significantly in compaction and particle size composition.

(d) It would be desirable for the average water salinities associated with the two or more shore areas to differ significantly.

II. Pre-vegetative Establishment Work.

(a) Elevation profiles should be established from the highest elevation to MLW through the center of each natural shore control and planting areas. A permanent bench mark should be established at each area and its elevation referenced to either MLW or MHW.

(b) Seeds of *Spartina alterniflora* for intertidal area vegetative establishment and of *S. patens* and *Distichlis spicata* for supratidal area vegetative establishment should be harvested upon ripening, thrashed, and stored in local estuarine water at 2 to 4 °C. It appears that *S. alterniflora* seeds are ready to harvest in Maine in September. As *S. patens* and *D. spicata* flower approximately one month before and after that of *S. alterniflora*, respectively, it is expected that seeds of these plants may be ready for harvest beginning August and October, respectively, and continuing as long as seeds are still attached to the plants (have not shattered completely).

(c) Mechanical analyses of the substrate associated with the natural shore control and planting areas should be accomplished.

(d) Water salinities and possibly other parameters of water quality should be determined at the various natural shore areas.

III. Vegetative Establishment Work.

(a) Seed sowing. Seeds should be sown in early spring after the threat of ice. *Spartina alterniflora* seeds should be sown from zero to two inches below the substrate surface along transects starting from MHW and ending at MLW. Both *S. patens* and *D. spicata* should be similarly sown at elevations above MHW. It may be of interest to sow seeds again in early summer in order to compare vegetative developments between the two sowing periods and, thereby, best define the optimum time for seed sowing.

(b) Soil plug transplants. Soil plugs of *S. alterniflora* taken from natural marsh areas should be transplanted in early spring at the project sites along a transect from MHW to MLW. Such transplantations should be repeated in June and in August. Similar transplantations of *S. patens* and *D. spicata* should be conducted at elevations above MHW.

(c) Bare root transplants. Vegetation from natural marsh areas should be excavated and washed free of associated soil. Shoot and rhizome sections should then be separated and planted according to the program given in section III-(b).

(d) Peat potted seedling transplants. Greenhouse peat pot cultivated seedlings of *S. alterniflora*, *S. patens*, and *D. spicata* from two to four months of age should be planted according to the program given in Section III-(b).

(e) Planting grid. It is recommended to use a three foot planting grid for all transplants: sections III-(b), -(c), and -(d).

(f) Fertilization program. Quadrats within the variously planted areas should be identified and subject to monthly fertilizations starting in June and ending in August. It is recommended to surface broadcast a fast dissolving fertilizer at low tide using an application rate of 336 kg/ha of N (ammonium nitrate) and 74 kg/ha of P (superphosphate).

(g) At the end of the first growing season, standing crop determinations should be made at various elevations and in each area subject to different methods of plant establishment; i.e., sections III-(a) through III-(d), and in areas subject to a fertilization program; section III-(f).

IV Other monitoring.

(a) If possible, water analyses (salinity, pH, nitrate, phosphate, iron, and amines) of the water associated with the various shore areas should be conducted in spring, summer, fall, and winter.

(b) Sampling benthic invertebrates should be conducted as a function of elevation in both the control and vegetated areas in the spring and then again in the late summer.

(c) Elevation profiles, established in II-(a) should be reestablished at the end of the growing season.

V. Project Report.

(a) Following the end of the first year's work, a report should be prepared that tabulates the experimental results and discusses salient correlations and conclusions.

In response to your letter of 16 October, Environmental Concern Inc. could supply you with marsh plant seedlings in peat pots, provided that viable seeds, locally harvested, were available. The cost per pot of 1½ - 2 month old seedlings (3-10 seedlings/pot) is $0.15, and that of 3-4 month old seedlings (3-10 seedlings/pot) is $0.35. This price excludes handling for shipping and shipping costs. The cost of plant material, therefore, ranges from $726/acre to $1,694/acre for 2 to 4 month old seedlings planted at three foot spacings. Trucking and handling costs would approximate 300 to $350 for 0.70 acre of 2 - month old plants and 0.35 acre of 4 - month old plants.

If I can be of any further assistance please let me know.

Sincerely yours,

Ed

Edgar W. Garbisch, Jr.
President

EWG:lfp

Cover photo by
Charter Weeks